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ABSTRACT

This discussion of games--particularly computerized games--and their potential in schools addresses several topics: what games are, types of games (free-form, rigid-form, or open-form) and their educational applications, the role of games in learning, student participation in adapting existing games for computer presentation, and special classroom management problems the teacher must plan for. This is one of a series of documents prepared as resources for the preservice and inservice training of teachers, and a 24-item bibliography is attached. (CMV)

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Illinois Series on Educational Application of Computers

INSTRUCTIONAL GAMES AND THE COMPUTER-USING TEACHER

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To the reader,

This is one of a series of documents prepared as resources for the preservice and inservice training of teachers. The general theme of all items in this series is "teaching with or about computers". The booklets are the collective work of a variety of staff and students (both present and former) of the College of Education, University of Illinois at Urbana-Champaign. The project generously was supported between 1977 and 1979 by a grant from the EXXON Education Foundation. All responsibility for the content of these documents rests with the authors and does not reflect necessarily the views of the EXXON Foundation. It was my extreme pleasure to direct the effort throughout.

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INSTRUCTIONAL GAMES

AND THE

COMPUTER-USING TEACHER

For most of us, a significant portion of our learning has come not from textbooks nor from listening to others teach, but rather from personal interactions with various contexts in an activity called play. In play, one collects a wide variety of experiences in a situation that usually is highly motivating. Although play usually is associated most closely with the learning of early childhood, there are many situations in adult learning and work that share these important attributes with play. At play, one frequently jumps to broad, sometimes unwarranted conclusions. One often becomes convinced of a "local truth", only to discover later that the logic from which that truth was derived cannot possibly work and then the process of guessing, visualizing, and conclusion-jumping starts over again.

Clearly, play has associated with it many of the characteristics that educators attribute to good education. One never can be passive at play. Play is one of the most active endeavors we know. At play, one easily identifies with the context, assumes roles and takes a degree of personal responsibility for the consequences. Play automatically is individualized. Each of us derives from play those attributes or experiences that our previous learning has equipped us to accept.

Increasing evidence of the use of games as teaching devices is being seen in education. Supply catalogs and professional publications frequently contain notice of a wide variety of such material. Texts are including more game type activities for diversion, for enrichment, or for core content instruction. The presence of such activities in instruction is not new, only the significant increase in their visibility.

To those already slightly familiar with uses of computers, it comes as no surprise that one of the frequent uses of computers is that of playing one of a variety of games. This activity is not always recreational. The field of artificial intelligence, attempting to recreate in machines the behaviors of humans, frequently has used the play of a game as one of those unique human behaviors.

In this paper we shall examine games, and particularly computerized games, for their potential in schools. To do this, we shall detail several topics, including what games are, what role games may have in learning, and the role of the teacher in the use of games.

WHAT IS A GAME?

To better understand games as potential learning devices, we shall look at them from two points of view. First, we shall present those attributes which games generally have in common. Then we shall present a taxonomy of games which serves to categorize games according to some of their varying attributes.

Definitions of games usually include the following attributes (Fletcher, 1971, 429-430).

1. A non-empty set of autonomous decision makers (called players).
2. A set of rules governing behavior choice.
3. A set of specified goals (payoffs).
4. A conflict among the players (competition).
5. A capacity to act and a pattern of preferences among behavior choices for each player.
6. An information system revealing the state of the game at all times.

Authors differ somewhat on the nature of the set of players. Some require the set of players to be composed of at least two members. The above definition permits the set of players to contain a single decision maker as would be the case in many one person card games. A player may be a person, a group of persons acting collectively, or a computer programmed to simulate the decisions of a player. A computer making the play of a game possible through a program, but not itself having a capacity to make play decisions would not be classified as a player.

For an activity to be a game, there must be more than a single decision that a player may make at each opportunity to play (a turn). From turn to turn, the set of available choices will vary among a number of alternate goals or a number of goal reaching strategies. These choices are determined and controlled by the rules of play.

Another important function of the rules is the specification of the goals of play. These goals determine the state that must be created to achieve the end of play and also the state that must be created to win play. These goals are distinguished by the fact that no two players may achieve simultaneously the winning state

of a game. This is what creates the conflict or competition element of a game. The conflict also may be created by the nature of the goal reaching strategies. When a winning strategy cannot be pursued by two players at the same time, then a conflict is created over achieving that decision point to initiate the valued strategy.

A player's capacity to act in a game is determined by the possession of a set of game related resources. A player exercises these resources each time he acts within the rules in an attempt to reach the winning state. It is these resources which determine the value system or currency of the game and the relative values of the various actions that may be invoked.

The information system of a game provides the data on state changes within the context of the game. This information is important when rationally selecting the portion of the resources to commit to a particular strategy. In some games, the information presented provides no improved decision basis for the player. In such games, the decisions always are arbitrary and their outcomes based entirely on luck. Most games provide at least some information on which to optimize play decisions. Amounts of this information may be hidden from a particular player because of his game behavior, so management of the flow of information through bargaining, negotiation, bluffing, or cooperation becomes important.

TYPES OF GAMES

There are three types of games most frequently found in learning settings. (Schulik and Brewer, 1972)

1. Free-form games
2. Rigid-form (content related) games
3. Open-form games

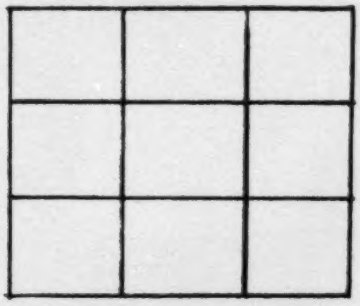
Free-form games are used widely in fields like sociology, political science, and social psychology. Such games are characterized by a scenario presenting a context within which play is to be developed. A distinguishing feature of this type of game is that positions, goals or objects, and even rules may be challenged, created, or altered during play. This flexibility of the game calls for the utmost in imagination and innovation in one's style of play. Free-form games permit interactions that enable the players to experience aspects of problems not described in the scenario.

An example of a free-form game used with secondary students is one involving the play of international relations. Different players are leaders of independent countries and through their actions attempt to compete with each other for control of important resources such as energy, natural materials, money, etc. Although decisions about actions against a competitor early in the game may be unencumbered, by making treaties or other agreements the rules are changed as the game progresses. However, it is clear that the decisions made are those frequently made by real governmental leaders. Seemingly similar decision points seldom are congruent enough to develop more than guidelines for making the decisions.

Rigid-form games sometimes are referred to as content-related or content-specific games. These games are among those most frequently computerized. Many instances of rigid-form games are found in business schools and in fields like economics, operations research, and in military training. The teaching of mathematics frequently is effected through rigid-form games. These are games in which play involves behaviors obviously congruent to those implied by accepted learning objectives of the instructional setting. In a rigid-form game, the rules and the objects collectively prescribe legitimate play and thus quite rigorously define the game. Exploration beyond the defined and bounded solution space neither is permitted nor even suggested. Pursuit of interesting alternatives involving alteration of game variables normally is not possible.

Examples of rigid-form games for use in schools abound. Scrabble is a rigid-form game that facilitates the practice of spelling. From mathematics, we have the following example:

> Use the digits 1, 2, 3, 4, 5, 6, 7, 8, 9. Take turns writing a digit in a square of the board. Use each digit only once. The winner is the first person to complete a row, column, or diagonal that totals 15.



This game practices the player on addition, but also calls for some strategies in the relative use of numbers.

Play of any game involves problem solving and the exercise of problem solving skills. In rigid-form games, the problems solved during play and the problem solving behaviors employed are congruent to real-life problems and problem solving skills. The problems solved are ones that have a stable structure in the sense that the problems occur, and recur, in the real-life counterpart of the game setting. So, behaviors learned and practiced in the game are precisely those needed and used in the real setting. Playing the game permits development and practice of solution algorithms.

For free-form games the situation is different. Although the problems involved are the same in type as problems from the real-life counterpart, no two of the problems ever are identical. Rather than specific solution behaviors that may be performed both in the games and the real-life setting, free-form games involve problems that are not static and thus require solution behaviors that are similar to, but not congruent to, the real-life solution behaviors.

Open-form games are those in which neither the problems solved nor the behaviors employed are congruent to any real-life counterparts. Good players of the game clearly have different behaviors than beginners, but how those behaviors relate to solution of real-life problems is not clear. Whereas the rigid-form games involve what we may refer to as specific, context related problem solving behavior and the free-form games involve general, context related problem solving behavior, open-form games

may be characterized as involving general, context free problem solving behaviors.

A good example of an open-form game is chess. Much problem solving and much learning takes place on the road to becoming a good player. People for some time have argued that chess playing has positive influences on mathematical behaviors, particularly those associated with geometry courses. Whether this is so, or how chess helps one to be good in geometry, or even what learnings are required to make a good chess player have not been demonstrated.

Free-form and open-form games permit richer, more imaginative, and potentially more creative exploration of the problem space of a context. However, this greatly reduces the control one has over the behaviors learned or practiced. Rigid-form games are more like activities permitting practice of specifiable activities. These games are understandably more attractive for school use since they are more easily related to the prevailing learning objectives. However, while rigid-form games are more easily administered in an instructional setting, the open-form or free-form games tend to be more "realistic" in terms of the behavior required for success. The international relations game described earlier presents a "real world" environment. Problem-solving strategies, as found in this type of activity, require the flexibility to adjust to fluctuations in the rules. One who cannot develop flexible contingency-type strategies ends up losing the contest.

Rigid-form games tend to reflect a "school reality." Such constraints as method, answer form, precision, syntax, answer length, speed, etc. are not typically real conditions. Numerical solutions apart from a context (and hence, an interpretation of the numbers in that context) are a characteristic of the contrived nature of school games. Problem solving in the real world is not static or one-dimensional as rigid-form games usually appear to be.

GAMES IN INSTRUCTION

To be of value in instruction, one should be able to determine learning or motivational outcomes of an activity. Without these learning outcomes, few activities can be perpetuated for very long in a school. This is a problem in the case of games, for although most will agree that a game teaches (i.e. results in a behavior change as a result of play), it usually is difficult to pinpoint the precise nature of the behaviors learned and is even more difficult to determine how the game teaches. The situation has been described by Boocock and Schild (1968):

> "the game designers are in the peculiar position of having a technology, or applied science, before the theoretical science has been developed. While most observers would agree that games do teach, what they teach and why are yet to be precisely measured."

A number of claims have been made about games in learning environments (Fletcher, 1972). One of these is that they are self-judging--the outcome of the game decides the winner(s). A player knows if he/she has won (lost) by his/her own actions. On a comparative basis, the implication of this claim (Fletcher, 1972, p. 433) is that games "provide feedback which is from the players' perspective at once more lucid, less arbitrary, and probably faster than that provided in other instructional settings, particularly by a teacher in an ordinary classroom."

Others claim that the role of the teacher is changed in a gaming environment. The teacher's role is transformed due to the self-judging nature of games, and it is claimed that this difference is good. "The dual role of the teacher as both teacher and judge is a structural defect of the school. A teacher has not only the task of teaching students, but also the task of giving them grades, grades that can greatly affect the students' futures. As a result, students develop attitudes toward the teachers that can interfere greatly with learning: hostility, servility, alienation, and other reactions to an authority figure. (With games) the teacher can escape from the role of judge, and return to his original function, that of a teacher, or helper for the student" (Boocock and Coleman, 1966). This claim has yet to be demonstrated, and some of the arguments appear weak. It is unclear how teachers can avoid giving grades in school simply by using games. It also is possible that a number of students will resist playing games, either because they find the notion of competition threatening, or because they regard the idea of game-playing as unsatisfying. If a teacher requires such students to participate in game-playing, the hostility and alienation of

any other standard assignment may be elicited. However, Twekler (1972, p. 153) has pointed out that "Teachers 'turned on' by simulation (games) become instructional managers interested not only in imparting information, but with creating an instructional climate that challenges the students' will to learn, and this aspect in itself would be worth all our efforts."

A third claim is that game-learning always is relevant. Two reasons are given why games are relevant (Boocock and Coleman, 1966):

1) Games provide an immediate goal for which the content of learning in the classroom is relevant.

2) Games provide the opportunity to practice roles which students see as important for their future lives.

Considerable anecdotal evidence and some research evidence (Robinson et al, 1966) indicate that the above behaviors do take place in game situations. These findings also are used to claim that games are "motivating" devices.

Clearly there are many games in which students take roles they otherwise will never play (e.g. the leader of a country or the president of a large corporation). Indeed, they may be asked to play roles they feel are unimportant or unnecessary. The simplifications introduced into games make tenuous any direct relationships between skills demanded by the game and those of actual practice. One of the potentially powerful aspects of games, however, would seem to be that within the context of the game, participants are forced to face the consequences of their actions. However, games usually tend to reward those who "think" like the designer of the game and punish those who develop innovative strategies. Instructional games rarely exhibit the flexibility of strategy development found in older, more widely played games such as chess. Games are thus useful in developing behaviors which are similar to an existing "model" and may not be useful for exploring possible alternatives to the model. If alternative processes or strategies are to be developed, one must remove the "competitive" nature of the lesson. Simulations are useful in this respect. They are, in effect, games without competition.

A number of claims have been made about what games can teach, or what game-players can learn. However, few of these claims have been demonstrated through research. Fletcher (1971) discusses the qualities which games are purported to improve:

1) motivation

2) skills (both interpersonal skills like communication, persuasion, negotiation, and advocacy, and skills dealing with the manipulation of information, such as in decison-making, rational strategy selection, and resource allocation)

3) various kinds of knowledge (including knowledge of facts and principles, knowledge of the outcomes of various strategies, and knowledge of the structure of the underlying model of the game)

4) self-awareness (in terms of personality and personal values)

5) attitudes

6) understanding.

On the basis of current research, two major conclusions about games used in instruction seem justifiable. These are that:

1) Games generate more interest in the subject matter than do more conventional classroom activities

2) Games are not necessarily better than conventional classroom methods with respect to imparting content.

Some advocates of educational games have suggested (on the basis of these research results) that games, per se, may be limited in their learning effects and that games need to be linked to some other instructional methodologies such as group discussion (Boocock and Schild, 1968). It has been claimed, but not demonstrated, that the discussion of a given game experience is necessary in order to maximize learning outcomes (Abt, 1968; Boocock and Schild, 1968; Harry, 1969). It also has not been shown that signigicant learning occurs through more rounds of game play.

It may be that games are more effective in teaching certain "intangible" concepts [such as McKenny's (1962) "planning concepts" or Strother et al's (1969) "awareness"] than in teaching explicit facts and relationships as found by Moore (1967). This raises a critical point (Greenlaw and Wyman, 1973): "strong 'learning' in games may not necessarily be reflected by good

gaming performance; conversely, absence of learning may not be reflected by 'poor' performance."

Games have been shown to be effective in changing student attitude (Boocock and Schild, 1968; Chartier, 1972) by making it more positive. There is even some research to support the use of games as a practice medium (at least in mathematics). Weusi-Puryear (1975) found that games in mathematics practice have a large enough motivational effect to significantly increase student achievement. The context of this study was a computerized drill and practice lesson in elementary mathematics. Students were given arithmetic problems to solve, and problems solved correctly resulted in an opportunity to make a move on a tic-tac-toe board. Incorrect answers resulted in a lost turn. The opponent of the game was a computer. Students were permitted to continue playing the game only if they correctly responded to randomized arithmetic exercises. In such an environment, not only was achievement superior among the game-players but they did fewer actual practice exercises to achieve the results.

Boocock and Schild (1968, p.151) point out that for a game to produce learning it should be constructed so that the skills, insight, or facts to be learned clearly are needed by the player in order to succeed in the game. They argue that games reduce the differential learning rates for low, average, and high ability students. Game playing is said to result in comparable levels of learning by students of all ability levels.

Data have been presented that show the importance of using a game correctly to maximize it's benefits. Inbar's (1966, p. 26) research led to this conclusion:

> "In overcrowded groups the players learn the rules of the games less efficiently, interact less, are less interested in the session and participate less actively in it; as a consequence, they tend to play a lesser number of moves and the impact of the game is weaker."

COMPUTER GAMES IN THE CLASSROOM

In this section we address more everyday concerns of the classroom teacher relative to games. First we shall discuss points concerning management of the classroom involving computerized games. There are two modes in which games may be of value to learners: 1) as a teaching activity executed by the learners, and 2) as a project designed and constructed by the student. When using games in the first of these modes, all students have a somewhat common experience in the sense of the activity space available to them. When students are permitted to create games, however, each of them has a much more unique learning experience, but one that is very difficult to classify within typical school objectives.

One mode in which a student may participate in the game creating process is to computerize a game found in some other setting. Computerizing a game can be a useful experience for a student. However, the teacher should be aware of some of the problems involved in such an assignment. Initially the teacher must address the problem of programming the game for the computer. If the students possess no programming ability, the teacher will have to teach a computer language. In fact, games are a very useful exercise content to use when teaching programming. The procedures, rules of play, and strategy for simple games generally are familiar to all students and thus form an easy "problem definition." They also contain examples of the necessary structures found in a programming language (printing or "outputting" data, inputing values, evaluating expressions, testing if-then-else relationships, generating random numbers, repeating moves through "loop" structures, etc.).

The game to be computerized should be one that is easy to represent on a computer terminal. Board games usually are not easily played on most computer systems, due to the problem of generating a picture of the board. Some systems (e.g. PLATO at the University of Illinois) allow for more easily designed graphic displays useful for board games. One way to circumvent the display problem on other systems is to reproduce individual "cells" of the board. However, this tends to be an ineffective design and makes strategy development more difficult since a mental picture of the complete board must be maintained without direct reference to a complete model. Non-board games (e.g. the word game "Hangman") usually are more easily adapted to computer play.

Another consideration for the game using teacher, is how the computer participates in play of the game. Initially, a computer game program should be designed so that one player plays against another player (or against himself) rather than against the computer. At this early design stage, the computer is used only

to record moves made by human players. It is a much more difficult task to analyse the entire strategy behind most games and to write an algorithm for the computer to use to play against a human. Even a game as seemingly simple as Tic-Tac-Toe has a rather complex decision algorithm (sometimes called a decision "tree") for controlling play. To ask students to develop a "play against a computer" game may provide them with a very frustrating problem.

Up to this point the discussion has centered on adapting an existing game for presentation by a computer. The possibility also exists for students to "invent" a new game to play. Creating a uniquely new game is an art similar to creating a painting, a poem or a short story. It is not something that can be accomplished easily by all people. However, inventing a new game is an exceptionally good instructional experience since it usually involves many problem solving activities. If the game involves, in either play or design, content of current interest then it becomes an even better instructional tool. Also, a game designed by a class member can be more interesting and "fun" for the other class members to play than an existing "professionally" designed game.

There is a general rule which should be observed when evaluating, adapting, or creating a game for instructional purposes:

> Use content of current interest as an integral part of the game (e.g. as a part of the strategy, in the decision making to determine moves, as the evaluator in determining a winner, etc.) and not as an incidental part of the game.

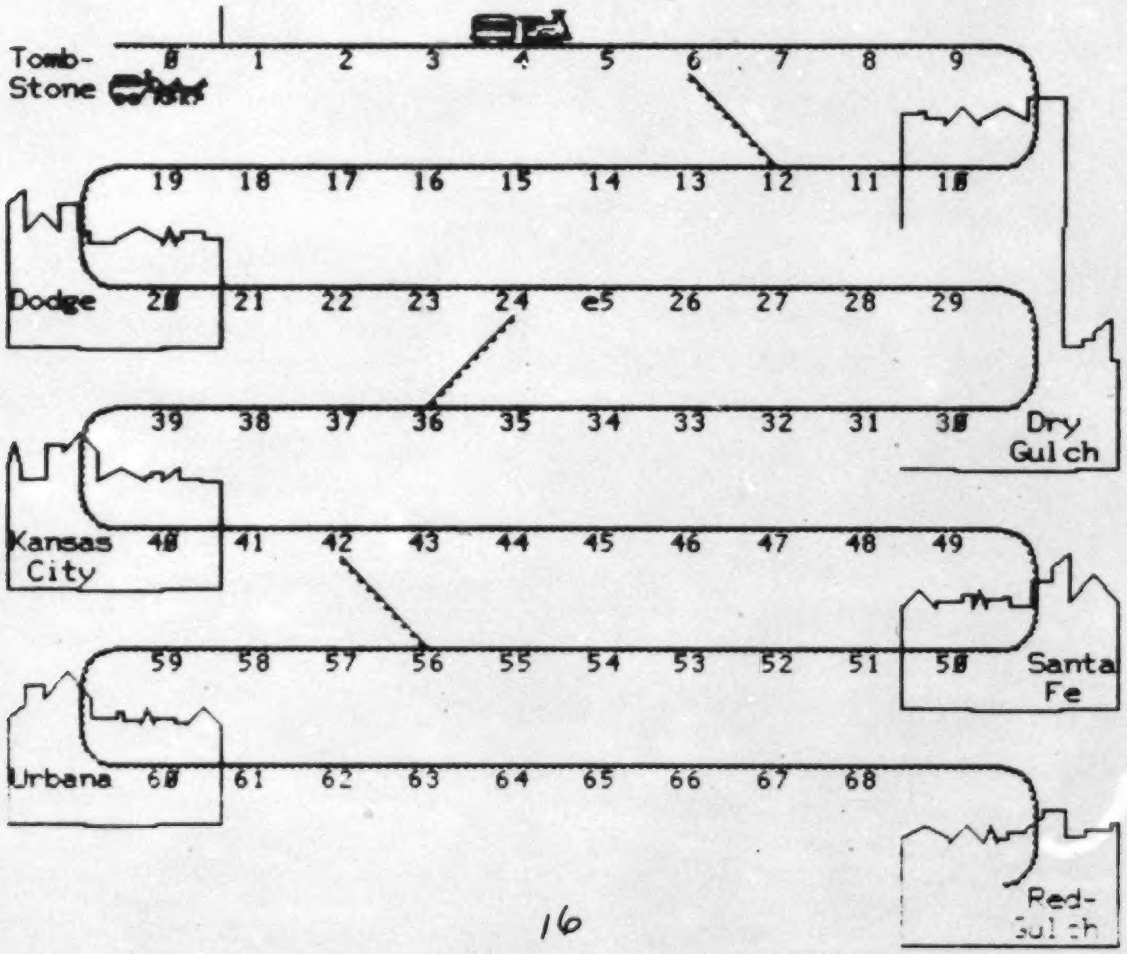
Following are examples of a well-designed and a poorly designed game in this respect.

"LOCOMOTIVE's Turn:"

Your numbers: 1 1 2

Your move: (1+1) ×2 = ➤ 4

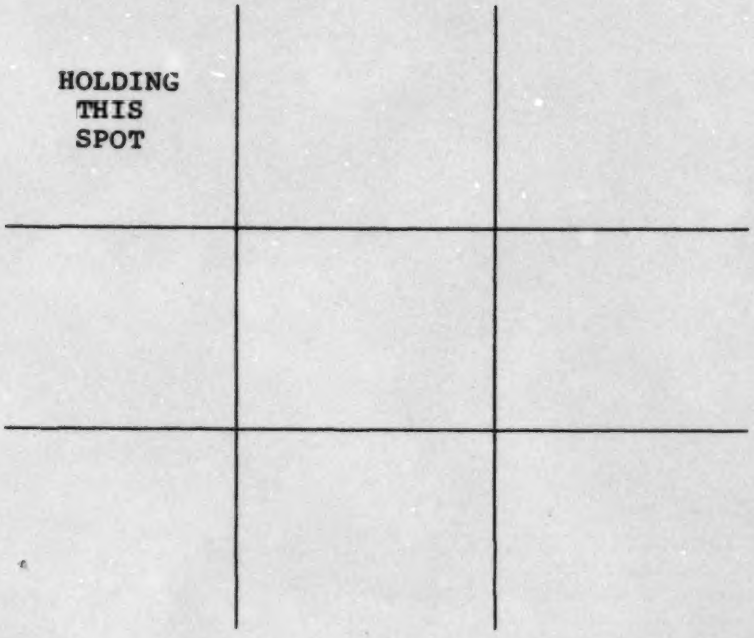
Press -NEXT-



WEST

PANIC
BUTTON

press to
resign



Answer Question Correctly to get that Spot!

QUESTION:
The statement, "remove the backing plate, the cylinders, and the piston" would probably NOT be found in a/an

a. abbreviated T.O.
b. methods and procedures T.O.
c. time compliance T.O. >
d. technical manual

TIC TAC T.O.

In the game WEST, the "move" decision uses mathematical expression construction and number relationship practice as a part of the game. This content cannot easily be removed from the game and preserve play of the game. Play of WEST is inherently tied to application of these mathematical concepts. The TIC TAC T.O. lesson uses the content as a "move" decision also. However, the content could be replaced by any other content to decide play of the game. The instructional content is not an integral part of the game but is only incidental to it. Both games are probably fun to play, but WEST is the better instructional game. Its instructional content has both meaning and relevance to success in the game.

Computerized games almost dictate interactive use of computer terminals. Sometimes games are designed so that opposing players share the same terminal but, even then, utilization of the device requires relatively long periods of time for only a few students. This serves to aggravate a teacher's management problems. On the one hand, an attempt to provide each student with a game experience either requires many terminal devices or else must be spread over several days. While this is happening, however, all other students in the class (those whose turn is over or still ahead) must have productive activities to pursue.

Utilization of games in the classroom, except possibly with certain rigid-form games, sometimes is difficult to justify and requires extreme foresight and planning by the teacher. We have said that games are motivating and exciting and thus may tend to compose the memorable events of the day. However, students seldom remember the instructional purpose behind the game being included as a class activity. Sometimes the teacher also will have no specific reason for including a game except as a diversion. Both from a public relations point of view and from a learning point of view, when games are used there must be a thoughtful plan that includes organizing activities preceding the game, and summarizing and relating activities following the game.

SUMMARY

Games are among the more popular uses of computers by both young and old. Although limited, there have been demonstrations of the motivating power of games to the extent of significantly improving learning during what essentially are practice sessions. In the classroom, however, games create management problems that require special attention and planning by the teacher.

STUDY ACTIVITY

1. Find a game being promoted for use in a subject you will teach. Identify as many of the learning outcomes of the game as you can. Discuss how you would integrate the game with other classroom activities.

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